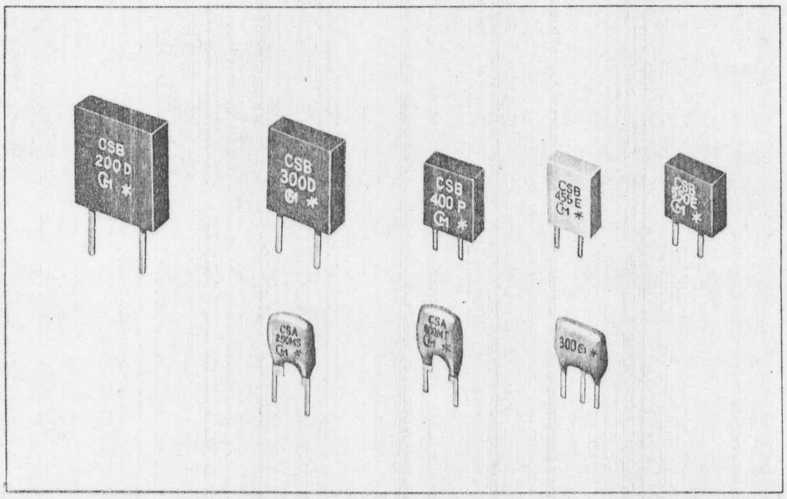
CERAMIC RESONATOR-CERALOCK®

MANUAL

CERALOCK APPLICATION



muRata

MURATA MFG.CO.,LTD.

Introduction

The Ceramic Resonator ("Ceralock" is being applied as the trade mark of MURATA) is a resonator made of high stability piezo-electric ceramics.

Long years' mass production of piezo-electric ceramic filters has enabled MURATA to produce "Ceralock" as stabilization components in oscillator circuits. Its stability lies between the crystal oscillators and CR/LC oscillators and keen attention is now being given to application of clock resonators for a variety of micro-processors represented by 1-chip micro-computors, thus broadening rapidly its application range.

The progress of semiconductor technology has made the control of a variety of equipment by means of piece of IC possible, which had been processed only by a large capacity computer. Since its cost has been reduced, micro-processors are more widely utilized in the field of industrial equipment as well as consumers equipment. It can be expected that the field of application will be expanded more in the future. To meet these growing needs, MURATA has developed "Ceralock", the clock resonators indispensable to these micro-processors offering stability, non-adjustment performance, miniature size and cost-saving.

This application manual is issued to use our "Ceralock" effectively without difficulty. We hope that this manual will prove to be of use when examining the application of the clock resonator to micro-processors and the like.

1. Performance of "Ceralock"

Although "Ceralock" could be manufactured to perform between a range of 190 to 800 KHZ and 2.5 to 30 MHz, each oscillation mode to be applied is different depending on the KHz range and the MHz range. Accordingly, the performances and configurations of each "Ceralock" differ each other. The specifications of KHz range "Ceralock" is shown in **Table 1**.

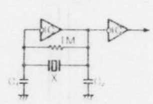
Item	Specification
Oscillation frequency Initial tolerance	±1KHz (190 ~ 375 KHz) ±2KHz (375 ~ 800 KHz)
Oscillation frequency Temperature stability	± 0.3% max. (−20°C ~ +80°C)
Aging (10 years)	± 0.5% max. at room temp.
Standard measuring circuit 	IC : 1/6 CD4069BE×2 V_{DD} : 5 V (Supply voltage) X : Ceralock C_1, C_2 : Loading capacitor

Table 1. The specifications of KHz range "Ceralock" (CSB series)

Note: Oscillation frequency can be adjusted in the specified circuit.

In the case of KHz range "Ceralock", "Area Vibration mode" of piezo-electric ceramics is applied. Accordingly, the configurations depend on its oscillation frequency, and also values of loading capacitor C_1, C_2 for oscillation circuit too. They are shown in **Table 2**.

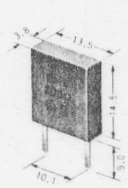
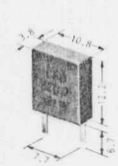
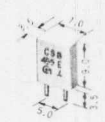
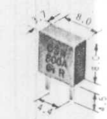
Frequency range		190 ~ 250KHz	250 ~ 375KHz	375 ~ 430KHz	430 ~ 504KHz	505 ~ 800KHz
Configuration (Unit: mm)						
Loading capacitor	C_1	330pF	220pF	120pF	100pF	100pF
	C_2	470pF	470pF	470pF	100pF	100pF

Table 2. The configurations and loading capacitors of KHz range "Ceralock" (CSB series)

The specifications of MHz range "Ceralock" is shown in Table 3.

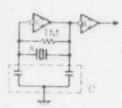
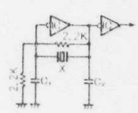
<table>
<tr><th>Item</th><th>Specification</th></tr>
<tr><td>Oscillation frequency
Initial tolerance</td><td>± 0.3% max.</td></tr>
<tr><td>Oscillation frequency
Temperature stability</td><td>± 0.3% max. (−20°C~+80°C)</td></tr>
<tr><td>Aging (10 years)</td><td>± 0.5% max. at room temp.</td></tr>
<tr><td colspan="2">Standard measuring circuit
CMOS clock circuit

IC : 1/6 CD4069BE×2
V_{DD}: 12 V (Supply voltage)
X : Ceralock
C : CSC
TTL clock circuit

IC : 1/6 74LS04×2
V_{cc} : 5 V (Supply voltage)
X : Ceralock
C_1, C_2: Loading capacitor</td></tr>
</table>

Table 3. The specifications of MHz range "Ceralock" (CSA series)

Note 1 Oscillation frequency, initial tolerance and temperature stability when combined with CSC
2 "Ceralock" in the customer's specified circuit other from the above test circuit is also available
3 Stability of oscillation which depends on IC to be used is subject to inquiry.

In the case of MHZ range "Ceralock", "Energy trapped thickness vibration mode" of piezo-electric ceramics is applied. Accordingly the configurations have 2 types in accordance with its oscillation frequency, and also values of loading capacitor C_1, C_2 (or CSC) for oscillation circuit too. They are shown in Table 4.

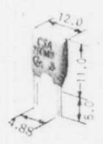
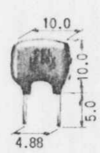
<table>
<tr><th colspan="3">Frequency range</th><th>2.5~3MHz</th><th>3~30MHz</th><th>10~30MHz</th></tr>
<tr><td colspan="3">Configuration
(Unit: mm)</td><td></td><td></td><td></td></tr>
<tr><td rowspan="4">Loading Capacitor</td><td rowspan="2">CMOS</td><td>C_1</td><td colspan="2">100pF/30pF</td><td>————</td></tr>
<tr><td>C_2</td><td colspan="2">100pF/30pF</td><td>————</td></tr>
<tr><td rowspan="2">TTL</td><td>C_1</td><td>470pF</td><td>470pF~220pF</td><td>220pF~33pF</td></tr>
<tr><td>C_2</td><td>1000pF</td><td>1000pF~220pF</td><td>220pF~33pF</td></tr>
</table>

Table 4 The configurations and loading capacitors of MHZ range "Ceralock" (CSA series)

In the case of using MHZ range "Ceralock". (CSA series) with CMOS circuit, the stability of oscillation frequency is influenced greatly by the temperature stability of loading capacitor C_1, C_2.

Therefore temperature compensating capacitor (CSC) is available to CSA series. The specification in Table 3 is in the case of using "Ceralock" with CSC. When other capacitors are used, its frequency tolerance has become about double. The specifications and configurations of temperature compensating capacitor (CSC) are shown in Table 5.

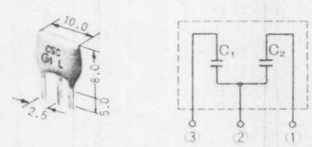
<table>
<tr><th>Item</th><th>Specification</th></tr>
<tr><td>Nominal capacitance</td><td>100pF×2 or 30pF×2</td></tr>
<tr><td>Tolerance</td><td>± 10% max.</td></tr>
<tr><td>Temperature coefficient</td><td>P4400 ± 1000ppm</td></tr>
<tr><td>Configurations and composition
(Unit: mm)</td><td></td></tr>
</table>

Table 5 The specification of CSC

Their mechanical properties and environmental stability are shown in Table 6.

Test items	Test conditions
Vibration resistance	Apply vibration of 10 ~ 55 Hz in frequency and 1.5 mm in amplitude in 3 perpendicular directions, X, Y and Z, for one hour each.
Shock resistance	Let specimen fall from a predetermined height to the concrete floor 3 times.
Heat resistance to soldering	Dip leadwires into solder bath of 350 ± 10°C to a depth of 2 mm below the bottom of the body for 3 seconds.
Solderability	Dip leadwires into solder bath of 230 ± 5°C to depth of 2mm below the bottom of the body for 5 seconds.
Pull strength of terminal	Pull leadwires along axis with 1 kg force for 5 to 10 seconds.
Humidity resistance	Hold specimen in the humidity chamber at a temperature of 40 ± 2°C and a relative humidity of 90 to 95% for 1000 hours.
Storage at high temperature	Subject specimen in the thermo chamber at a temperature of 85 ± 2°C for 1000 hours.
Storage at low temperature	Subject specimen in the thermo chamber at a temperature of −25 ± 2°C for 1000 hours.
Temperature cycle	5 cycles test of 30 min. at −55°C, 15 min. at +20°C, 30 min. at +85°C and 15 min. at +20°C.
Thermal shock	5 cycles test of 30 min. at −55°C and 30 min. at +85°C, changing within 10 sec. air to air.

Table 6. Mechanical properties and environmental stability of "Ceralock"

Note: 1. After undergoing tests under each of the above testing conditions, each specimen shall meet specifications as shown in Table 1 and Table 3.
2. The above testing conditions conform to MIL-STD-202E.

2. Principles of "Ceralock"

"Ceralock" is a kind of mechanical resonator made of piezo-electric ceramics. By utilizing its stable specific frequency determined by the modulus of elasticity and mechanical dimensions, and an oscillation circuit having a stable frequency of approx. $10^{-5}/°C$ can be designed. The vibration mode is selectively used depending on the specific frequency required and, therefore, in the case of "Ceralock", "area vibration" is applied in KHz range and "energy trapped thickness vibration in MHz range.
In this section, a brief description of the operating principle of "Ceralock" is mentioned.

2-1 Equivalent circuit for "Ceralock"

The basic method of using "Ceralock" in its application is two-terminals type resonator provided with a couple of electrodes as shown in **Fig. 1.** The impedance and phase characteristics measured between the two terminals are as shown in **Fig. 2.** It is illustrated in Fig. 2 that "Ceralock" becomes inductive in the frequency zone between the frequency fr (resonant frequency) which provides the minimum impedance and the frequency fa (antiresonant frequency) which provides the maximum impedance, and that it becomes capacitive in other frequency zone. This fact means that the mechanical vibration by the two-terminals type resonator can be replaced equivalently with a combination of series and parallel resonant circuit consisting of inductor: L, capacitor: C and resistor: R. In the vicinity of the specific frequency, the electrical equivalent circuit can be expressed as shown in **Fig. 3.** fr and fa show such frequencies as are determined by the parameters of piezo-

electric ceramics and the fabricating conditions. The equivalent circuit constants can also be determiend directly from the following formulas.

$$fr = \frac{1}{2\pi\sqrt{L_1\,C_1}}$$

$$fa = \frac{1}{2\pi\sqrt{L_1\,C_1\,C_0/(C_1+C_0)}} = fr\sqrt{1+C_1/C_0}$$

Considering the limited frequency zone of $fr \leq f \leq fa$, the impedance is given as $Z = Re + j\omega Le$ ($Le \geq 0$) as shown in Fig. 4. and "Ceralock" should work as an inductor Le (H) haivng the loss Re(Ω). In the case of "Ceralock", the value of equivalent inductance varies approximately from 0 to 10^5H in this frequency zone. By utilizing the fact that this action will selectively occur only in the frequency zone between fr and fa in the full frequency range, an oscillation circuit can be composed.

$Z = R+jX$: Impedance between two-terminals
$\tan^{-1}\phi = X/R$
ϕ : Phase

Fig. 1. Symbol of Ceralock

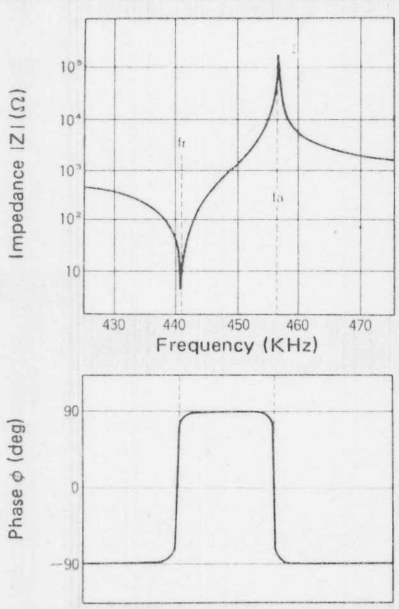
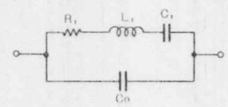


Fig. 2. Impedance and phase characteristics for Ceralock (CSB455E)

Equivalent circuit



R_1 : Equivalent resistance
L_1 : Equivalent mass
C_1 : Equivalent compliance
C_0 : Parallel equivalent capacitance

	CSB455E	CSA4.00MT
R_1	7.5Ω	6.0Ω
L_1	7.1mH	140μH
C_1	18pF	11pF
C_0	260pF	76pF
Qm	2500	600

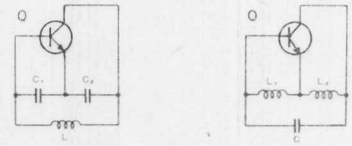
Fig. 3. Equivalent circuit for Ceralock

Re: Effective resistance
Le: Effective inductance

Fig. 4. Equivalent circuit for Ceralock at a frequency zone of $fr \leq f \leq fa$

2·2 Applciation of "Ceralock" to the oscillation circuit

A commonly used oscillation circuit comprises a tuning circuit consisting of inductor L and capacitor C, and an amplifier. Since this oscillation circuit (called LC oscillator) can be allowed to oscillate easily with a simple construction, it has a wide range of applications. However, there are limitations such as the stability of oscillation frequency which is approximately in the range of 10^{-3}/°C to 10^{-4}/°C due to the unstableness of the LC elements and that available values of inductor L are limited. For LC oscillator, Colpitts circuit and Hartley circuit are typically used. The principle diagram of such circuit is shown in Fig. 5. Refering to Fig. 5, the oscillation frequency is provided approximately by the resonant frequency of the tuning circuit determined by C_1, C_2 & L (Colpitts circuit) or L_1, L_2 C (Hartley circuit).



Colpitts circuit Hartley circuit

Fig. 5. Basic Construction of LC Oscillator

It is presumed that even if L or C in the LC oscillator in Fig. 5 is replaced with "Ceralock", the required oscillating conditions will be satisfied. Especially, by replacing the coil with "Ceralock", the oscillating conditions will be selectively satisfied in the frequency zone between fr and fa as being the specific frequency of "Ceralock". For this reason, in the Colpitts circuits where only a coil is normally used, a method in which the coil referred to above is replaced by "Ceralock" is widely adopted. The oscillating conditions can be obtained from the LC oscillator.

The stability of effective inductance provided by "Ceralock" is much higher than a coil as an electronic component. Resultantly, stability of the oscillation frequency less than $10^{-5}/°C$ can be obtained by optional selection of C_1 & C_2.

3. How to use "Ceralock"

The oscillation circuit design for the application of "Ceralock" depends on the use, IC to be applied. The basic circuit construction is the same as crystal oscillators. The circuit constants for "Ceralock" will be different due to the mechanical Q.

In this section, a method of applying CMOS inverter shown in **Table. 1.** as a standard operating circuit is mentioned.

3-1 Construction of basic oscillation circuit

Though such cases where an oscillation circuit is composed by use of digital IC are increasing, the most useful method is to utilize an inverter gate. In view of the above, the construction of a basic oscillation circuit applied with CMOS inverter is shown again in **Fig. 6.** Refering to **Fig. 6,** INV. 1 will operate as an inverted amplifier to which a bias voltage is applied through the feedback resistor Rf. Besides, INV. 2 is applied as a buffer amplifier for connecting to the frequency counter, etc. and as a wave-form shaping circuit. The external capacitor, C_1 & C_2, depend on the equivalent constants of "Ceralock" and the type of amplifier to be used. Each value of C_1 & C_2 when using CMOS inverter is shown in **Table. 2.** and **Table. 4.**

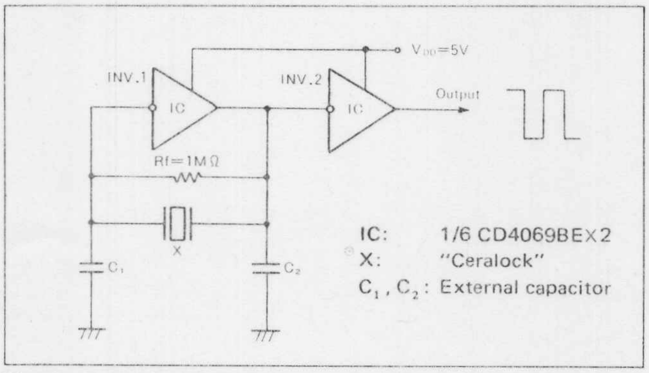


Fig. 6. Basic Oscillation Circuit of "Ceralock"

3-2 Determining component values in circuit

a. The mechanical Q (Qm) of "Ceralock" varies with the drift of ambient temperature. Therefore, each value of C_1 & C_2 should be selected so that "Ceralock" can work at the boundary of required operating temperature range. An example of the Qm-drift of "Ceralock" vs temperature is shown in **Fig. 7.**

b. Since "Ceralock" is a type of mechanical resonator, there is a so-called spurious oscillation caused by its inharmonic overtone. or by a different vibration mode. For this reason, precautions must be taken that such spurious oscillation may be caused by the selection of the frequency characteristic of an amplifier or the values of C_1 & C_2. This phenomenon is most likely to occur in the piezo-electric ceramics having high Qm and also to the "Ceralock" of KHz range (CSB type) due to its construction. An example of spurious characteristic of "Ceralock" is shown in **Fig. 8.**

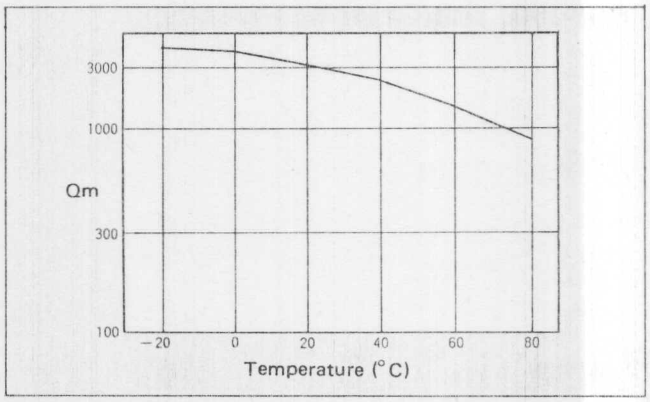


Fig. 7. Qm-drift of "Ceralock" vs Temperature (CSB455E)

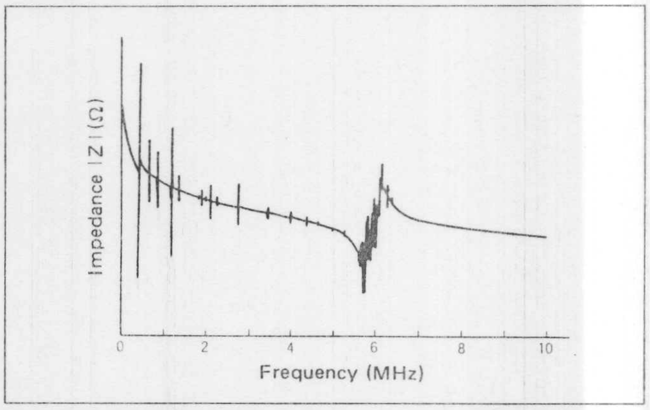
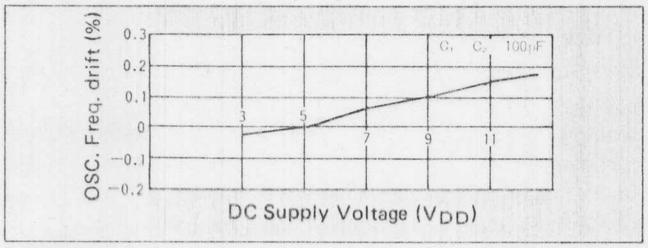


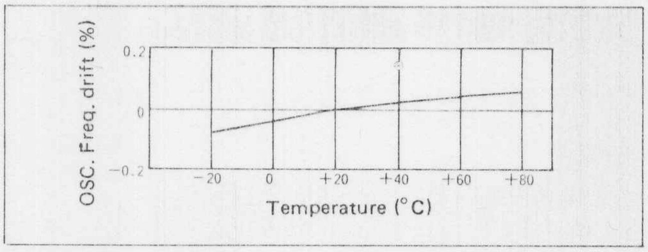
Fig. 8 Spurious Response of "Ceralock" (CSB455E)

3-3 Stability of oscillation circuit

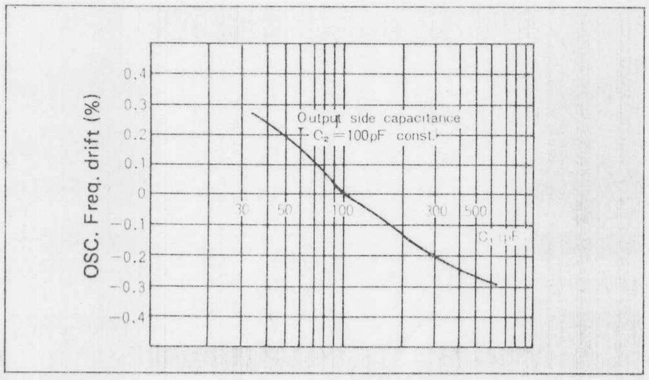
An example of oscillation frequency stability, when the oscillation circuit as shown in **Fig. 6.** is used, are shown in **Fig. 9.** The stability against supply voltage drift and ambient temperature drift are shown in **Fig. 9,** (a) and (b) respectively. Also, (c) and (d) show the drift ratio of oscillation frequency against respective change of C_1 & C_2.



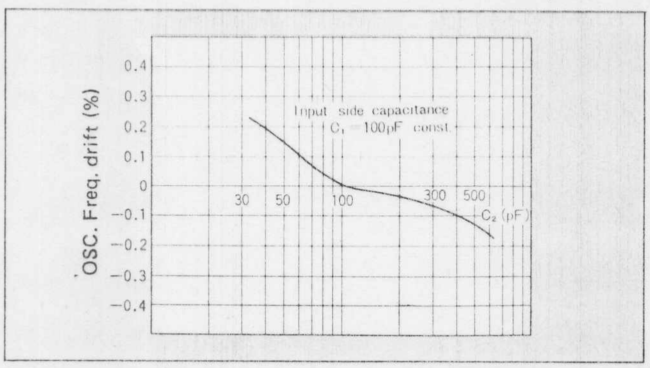
(a) Supply voltage dependability of oscillation frequency



(b) Temperature characteristic of oscillation frequency



(c) Oscillation frequency drift vs input side capacitance C_1



(d) Oscillation frequency drift vs output side capacitance C_2

Fig. 9. Oscillation frequency stability of "Ceralock" (CSB455E)

4. Features of "Ceralock"

"Ceralock" has the following features.

(1) A very suitable component for miniaturization

In crystal oscillator, HC-33/U-holder (19.3 X 9.0 X 19.8mm) is used for the KHz range and HC-12-holder/U (14.5 X 6.1 X 14.8mm) for the MHz range.

"Ceralock" offer the equivalent to this or more than miniaturized design.

(2) A high stability of oscillation frequency in a wide temperature range

The stability of the crystal oscillator is better than 10^{-6}/°C and that of the LC or CR oscillation circuit is in the range of 10^{-3} to 10^{-4}/°C. "Ceralock" however, offers a stability of 10^{-5}/°C in the temperature range of −20°C to +80°C.

(3) Capability of designing non-adjustment oscillation circuit

In the LC or CR oscillation circuit, an alignment process for oscillation frequency is required due to variations in components, whereas "Ceralock" offers non-adjustment operation with a tolerance of less than ±0.5%. In this case, "Ceralock" eliminates the use of trimmer capacitor or resistor so that, the manufacturing cost of the oscillation circuit can be reduced.

(4) Economical price

Since the manufacturing method of "Ceralock" is designed on the basis of mass production, economical price is being supplied.

5. Application Circuit Diagrams

Making the most of the above-mentioned features, the "Ceralock" has a wide range of applications when used in combination with various types of IC. Some examples of its practical application are shown below.

5-1 Application to Transistor TTL IC

A stable oscillation circuit can be obtained when "Ceralock" is used in combination with various active elements. Figs. 10 and 11 show Colpitts oscillation circuits using transistors. The load capacity of the transistors used are larger than that of MOS IC. In Fig. 10, "Ceralock" of 455KHz and in Fig. 11 that of 6MHz are used.

Figs. 12, 13, and 14 show examples of oscillation circuits using C-MOS inverters. Fig. 12 is a concrete example of the basic circuit construction described earlier in 3-1. Fig. 13 is a two-step inverter construction which oscillates at a frequency near fa (antiresonant frequency) as mentioned in 2-1. Fig. 14 is an application to an actual C MOS binary counter with a built-in oscillation inverter. Figs. 15 and 16 show examples of oscillation circuit constructions using TTL inverters with a larger load capacity than for the MOS type IC, while using a very small feedback resistance of about 1 ~ 3KΩ in comparison with several tens kilo-ohms to 1MΩ of the MOS type. Pay full attention to this fact in designing. Fig. 17 shows an example which uses the comparator type IC and forms the oscillation circuit using the inverted input side. The load capacity and feedback resistance are about the same as in the MOS type.

When an oscillation circuit uses "Ceralock", its oscillation frequency is influenced by its load capacity. In designing oscillation circuits, take these points into full consideration.

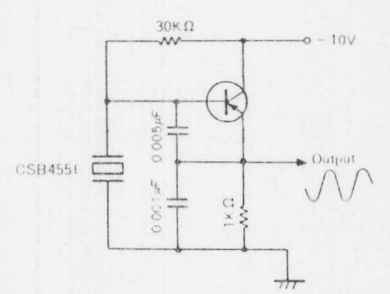


Fig. 10 Oscillation circuit applied with a transistor

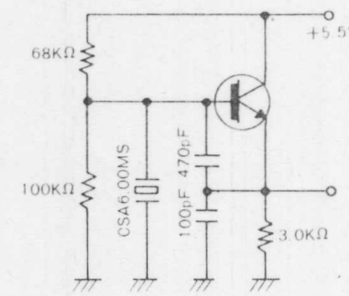
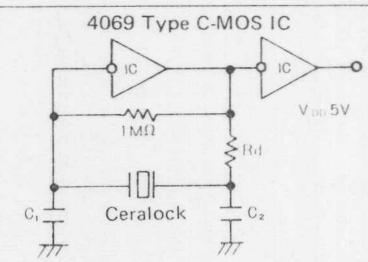


Fig. 11 Oscillation circuit applied with a transistor



CERALOCK	C_1	C_2	Rd
CSB200 D	470pF	470pF	6.8KΩ
CSB400 P	180pF	180pF	6.8KΩ

Fig. 12 Oscillation circuit applied with a C-MOS inverter

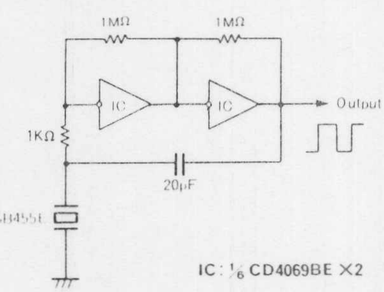
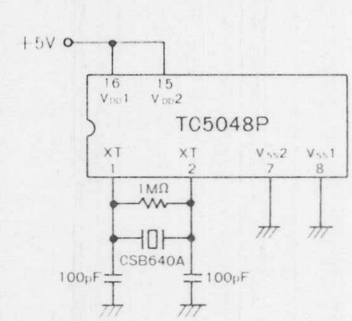


Fig. 13 Oscillation circuit applied with an inverter



A be able to supply various counter output on request.

Fig. 14 Application to TC5048P (TOSHIBA)

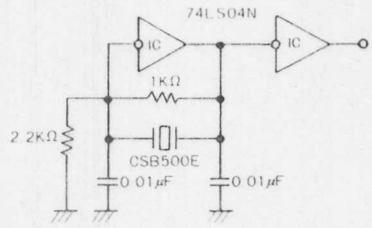
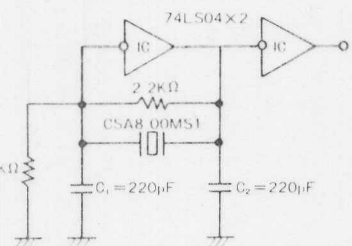
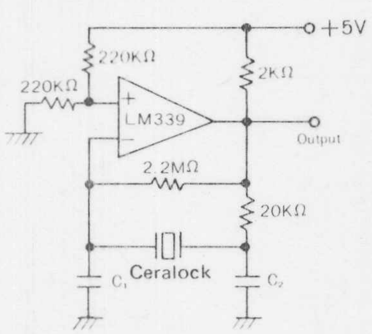


Fig. 15 Oscillation circuit applied with a TTL inverter



Values of C_1 & C_2 should be selected according to "Ceralock".

Fig. 16 Oscillation circuit applied with a TTL inverter



Ceralock	C_1	C_2
CSB200D	330 pF	470 pF
CSB400P	120 pF	120 pF

Fig. 17 Application to comparator

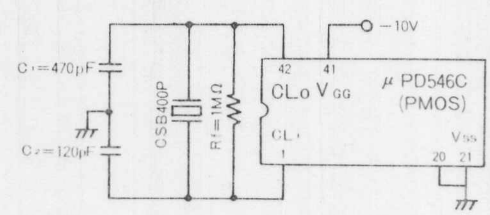
5-2 Application to various one-chip

"Ceralock" is the most suitable as a stable resonator for a variety of 4 bit and 8 bit 1-chip micro-computers.

(1) Application to P-MOS 1-chip micro-computer
Applications to μPD546C (NEC), TMS1000 series (T.I.) and M58881P (Mitsubishi) are shown in **Fig. 18**, **Fig. 19**, and **Fig. 20**, respectively. When designing, take into full consideration the fact that the use of "Ceralock" of a different frequency may sometimes require a change in the circuit constant.

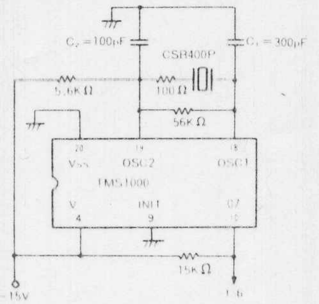
(2) Application to C-MOS 1-chip micro-computer
Applications to μPD650C (NEC), TMS1000 series (T.I.) and HD44800 (Hitachi) are shown in **Fig. 21**, **Fig. 22**, and **Fig. 23**, respectively. The same cautions as for P-MOS also apply in this case when using "Ceralock" of a different frequency.

(3) Application to N-MOS 1-chip micro-computer
The applications to 8048 series (Intel, etc.) is shown in **Fig. 24**, 8085 series (Intel, etc.) in **Fig. 25**, 6802 series (Motorola, etc.) in **Fig. 26**, MB8840 series (Fujitsu) in **Fig. 27**, μCOM40N series (NEC) in **Fig. 28**, μPD766G (NEC) in **Fig. 29**, and MK3870 (Mostek) in **Fig. 30**.
The application of "Ceralock" of 800KHz or less to N-MOS 1-chip micro-computers (application to μPD766G in **Fig. 29** is the corresponding example) tends to cause spurious oscillation as mentioned in 3-2b, and requires cautions when selecting the load capacity.
Use of a "Ceralock" of 2.5MHz or more, when the tolerance to the oscillation frequency temperature characteristics is small, requires the combined use of CSC. It is necessary to determine the capacity of CSC, which has two standard of 30pF X 2 and 100pF X 2, according to the IC used.



(Note)
1. Values of C_1 & C_2 should be selected according to "Ceralock".
2. Can be applied commonly for μCOM40 series.

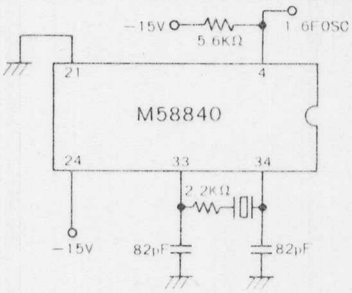
Fig. 18 Application to μPD546C (μCOM43) (NEC)



(Note)

1. Values of C_1, C_2 should be selected according to "Ceralock".
2. Values of resistor serially connected "Ceralock" should be adjusted according to the allowable input-output voltage.

Fig. 19 Application to TMS1000 (T.I.)



CSB500E, CSB600C can be applied too.

Fig. 20 Application to M58840 (MITSUBISHI)

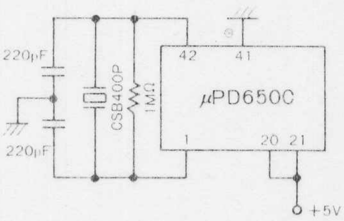
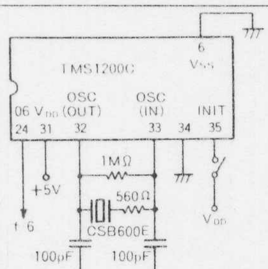


Fig. 21 Application to μPD650C (NEC)



(Note)

1. Values of C_1 & C_2 should be selected according to "Ceralock"
2. Values of resistor serially connected "Ceralock" should be adjusted according to the allowable input-output voltage.

Fig. 22 Application to TMS1000C Series (T.I.)

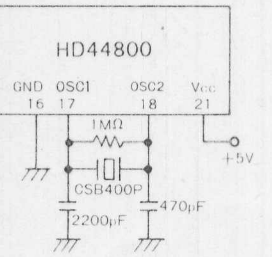


Fig. 23 Application to HD44800 (HITACHI)

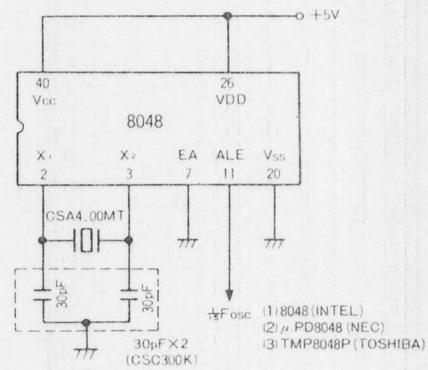


Fig. 24 Application to 8048

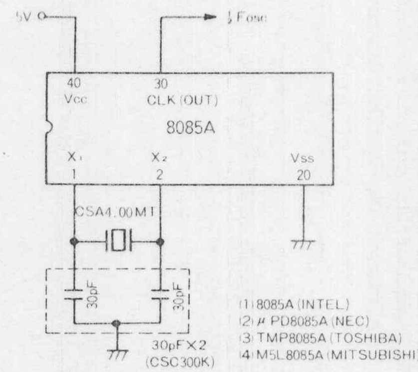
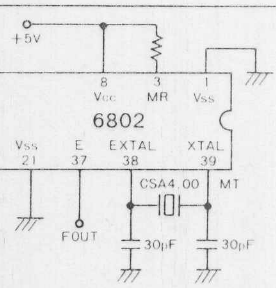
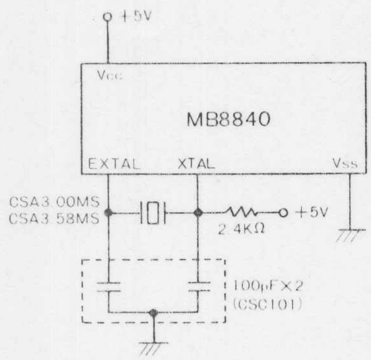


Fig. 25 Application to 8085A



(1) MC6802 (MOTOROLA) (2) HD46802 (HITACHI)

Fig. 26 Application to 6802



(Note)

- When ordering CSA3.00MS CSC101, please specify KMFC1033S as a part with number.
- When ordering CSA3.58MS and CSC101 as a pair, please specify the number of KMFC1001S.

Fig. 27 Application to MB8840 Series (FUJITSU)

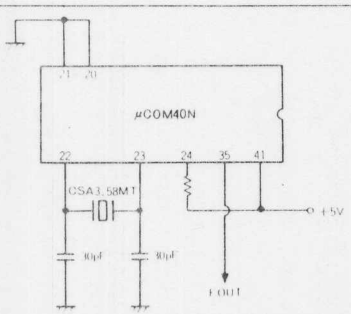


Fig. 28 Application to μCOM40M Series (NEC)

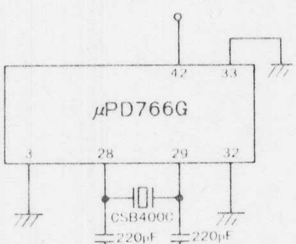


Fig. 29 Application to μPD766G (NEC)

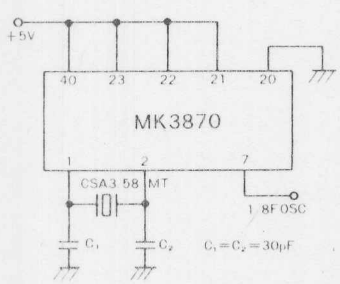


Fig. 30 Application to MK3870 (MOSTEK)

5-3 Application to Various IC

(1) Application to voice synthesis

Fig. 31 shows an application to HD38880 (Hitachi). This is the IC which is expected to be used in various applications in the future. It requires a control circuit by a micro-computer, but the various 1-chip micro-computers described in 6-2 and "Ceralock" can be used for this purpose.

(2) Application to various types of remote control

Applications to μPD1986C and 1987C (NEC) are shown in Fig. 32, and M58484P and 58485P (Mitsubishi) in Fig. 33. The use of remote control in TV's, stereos, VTR's, etc. is rapidly increasing. Our "Ceralock" is best suited for use in remote controls which are required to be compact and thin.

(3) Application to TV and VTR

a) Fig. 34 shows an application to IC LM1880 (NS) for the TV horizontal/vertical synchronizing signal generating circuit.

b) In its use in VTR, application to micro-computers in response to the needs for multifunctions, and reference oscillation for driving motors are also possible and have been put into practical use.

(4) Application to tone dialer

The application to MK5098P (MOSTEK) is shown in Fig. 35, AY-3-9410 (G.I.) in Fig. 36, and MK5087 (Mostek) in Fig. 37. The advantages of "Ceralock", namely its stability, small size, high reliability, and low cost are made the full use of.

(5) Application to other uses

Applications to M58881 (Mitsubishi) and μPD1290G (NEC) are shown in Figs. 38 and 39, respectively. These are ICs for use in electronic calculators with printers, and are also used in ECR's.

Fig. 40 shows its application to AY-3-1270 (G.I.). This IC is for thermometers and controllers, but the use of such type IC's for automatic instrumentation control is expected to increase.

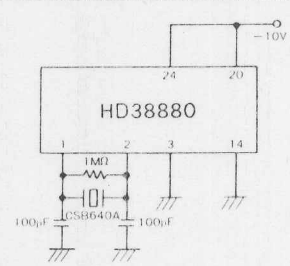
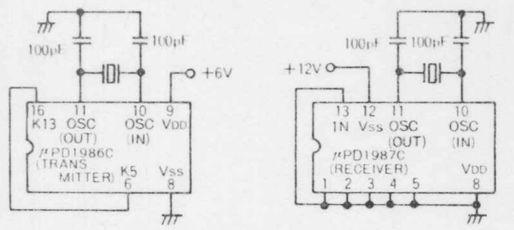
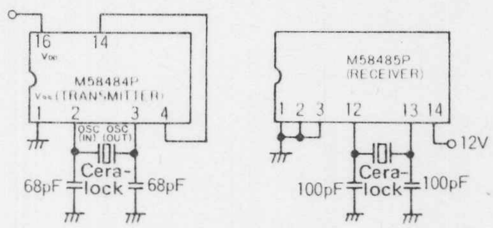


Fig. 31 Application to HD38880 (HITACHI)



CSB455E(C), CSB480E(A,C) can be applied too.

Fig. 32 Application to μPD1986C/1987C (NEC) (for various remote control)



CSB455E(C), CSB480E(A, C) can be applied too.

Fig. 33 Application to M58484P/M58485P (MITSUBISHI) (for various remote control)

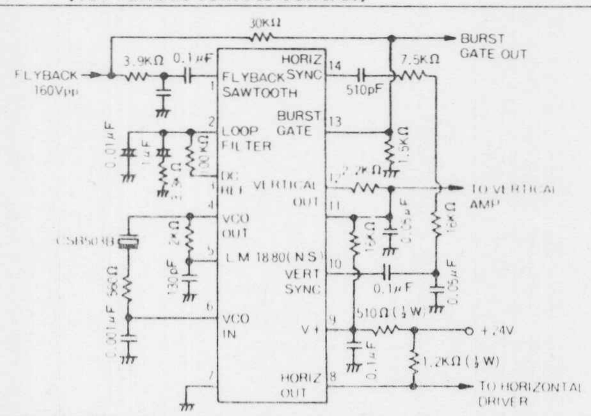


Fig. 34 Application to LM1880 (NS) (TV synchronization system)

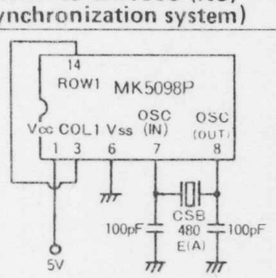
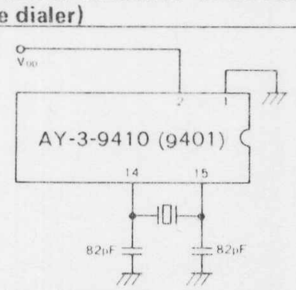


Fig. 35 Application to MK5098P (MOSTEK) (for tone dialer)



BFB560A (CSB560E) can be applied too.

Fig. 36 Application to AY-3-9410 (G.I.) (for tone dialer)

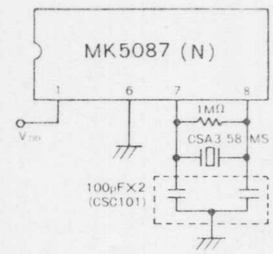


Fig. 37 Application to MK5087(MOSTEK)(for tone dialer)

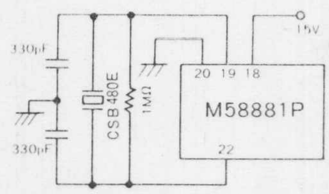


Fig. 38 Application to M58881P (MITSUBISHI) (for calculator with printer)

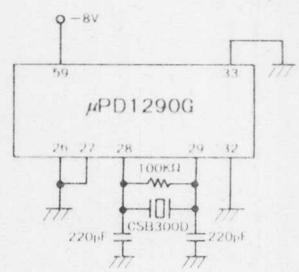
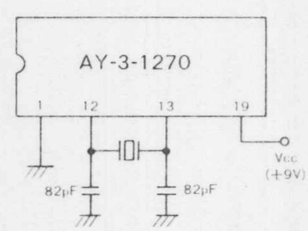


Fig. 39 Application to μPD1290G (NEC) (for calculator with printer)



BFB560A (CSB560E) can be applied too.

Fig. 40 Application to AY-3-1270 (G.I.) (Termometer and controller)